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Author(s): Usov, Igor Olegovich
Waschezyn, David M.
Vodnik, Douglas R.
Waked, Robert Ryan
Middlemas, Michael Robert
Schneider, Matthew M.
Holesinger, Terry George

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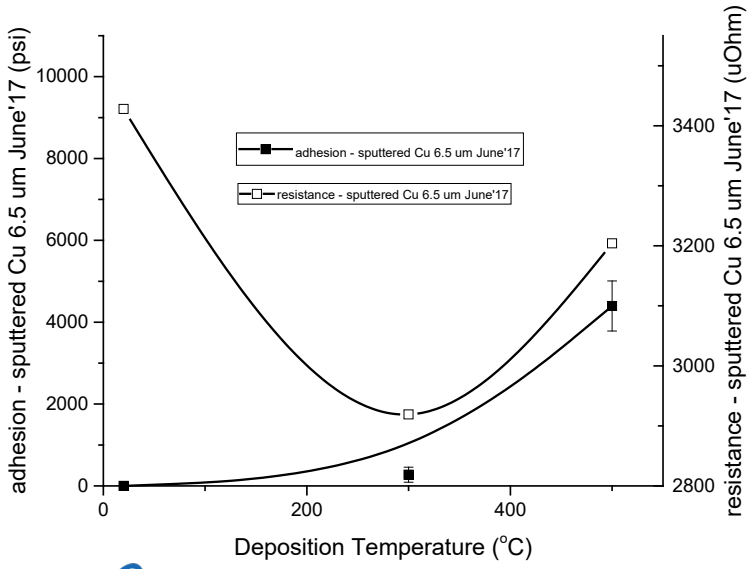
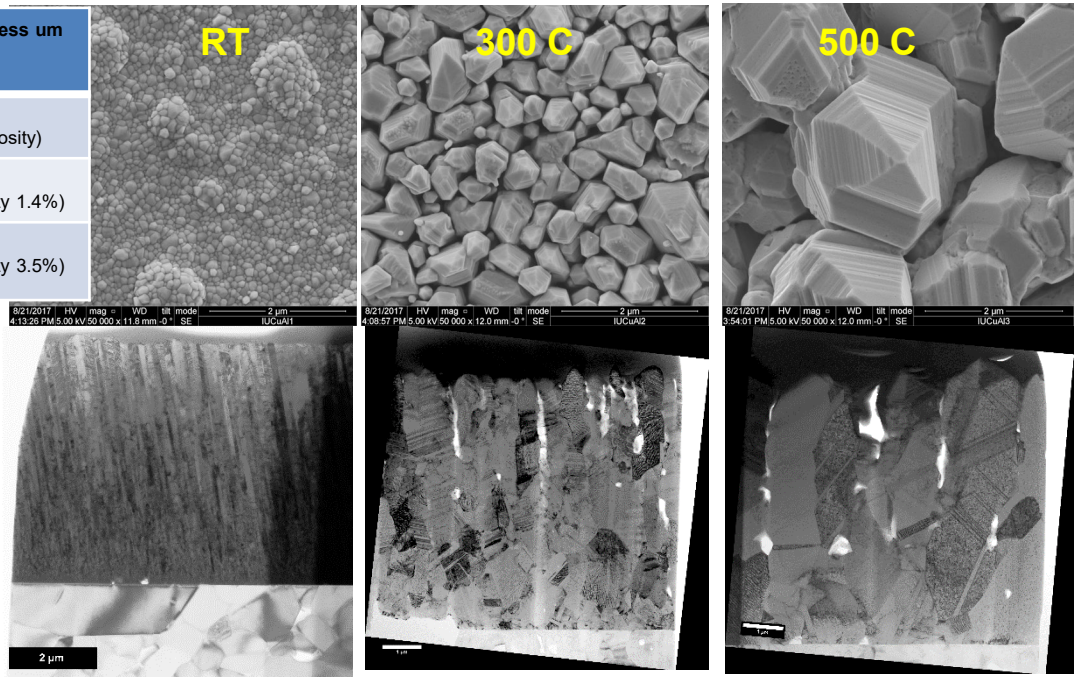
Adhesion, microstructure and electrical resistance of sputtered Cu films on alumina substrates

I. Usov, D. Vodnik (MST-7), R. Waked, David Waschezyn (DET-2), Michael Middlemas, Matt Schneider, Terry Holesinger (MST-16)

Run	Max. Adhesion Strength (psi)	R μΩ, Keysight	Thickness u"/um Oxford	Thickness um QCM	Thickness um TEM
6-8-17 Cu RT	0, 0 (delaminated during curing)	3428	132.5 / 3.35	6.7	5.48 (no porosity)
6-9-17 Cu 300C	405, 144 (274.5±184.5)	2919	158.1 / 4.1	6.9	6.45 (porosity 1.4%)
6-13-17 Cu 500C	4828, 3964 (4396±611)	3204	144.1 / 3.66	6.6	6.42 (porosity 3.5%)





- *Cu film thickness is grossly underestimated by using Oxford instrument (electrical resistance)*
- *Cu film thickness is in good agreement between QCM and TEM at 300 C and 500 C, discrepancy observed at RT is likely because QCM calibration was done at 500 C*
- *Electrical resistance depends on film thickness and microstructure (grain size, porosity, etc.)*
- *Adhesion is likely affected by contaminants, strain and porosity at the film/substrate interface :*
  - ✓ *At RT: amorphous layer(~ 4 nm, likely* initial alumina surface contamination), *porosity and significant strain*
  - ✓ *At 300°C: thin amorphous layer (< 1nm), no porosity and small strain*
  - ✓ *At 500°C: no amorphous layer, porosity and no strain*
- *Film microstructure and film/substrate interface can be controlled by deposition temperature*